Savannah River Remediation
AECOM | BECHTEL | CH2M | B&W | AREVA

INTEROFFICE MEMORANDUM

SRR-CWDA-2015-00100

Revision 2

September 1, 2015

TO: G. C. Arthur, 241-284H

FROM: M. H. Layton, 705-1C 9/1/15

REVIEWED BY: 9/2/2015

K. H. Rosenberger, 705-1C

EVALUATION OF THE USE OF AN ALTERNATIVE TANK 16 FILL GROUT (PER SPECIFICATION C-SPP-Z-00012)

Purpose

The purpose of this memo is to evaluate the proposed activity of using an alternative fill grout meeting the requirements of Specification C-SPP-Z-00012 while completing the final Tank 16 primary and annulus grout lifts (approximately two feet of tank space, a maximum of 84,000 gallons in primary and 10,280 gallons in the annulus). Use of an alternative grout formula with an increased grout flowability is desired in order minimize the potential for voids during the final Tank 16 grout pours.

Background

Bulk Fill Grout Discussion

Filling a cleaned tank with grout prevents possible future subsidence of the closed facility. The grout fill also helps to reduce water movement to the residual contaminants. Reducing the amount of water retards the migration of residual contaminants from the tank to the environment. Testing has demonstrated the chemical and physical characteristics of the grout formula used at SRS. HTF tank closure activities typically use reducing grout, with low reduction potential (Eh), thus minimizing the mobility of certain radionuclides after closure. All grout formulas are alkaline because grout is a cement-based material that naturally has a high pH which is compatible with the carbon steel waste tank liner. The tank fill grout also has high compressive strength and low permeability, enhancing its ability to limit the migration of infiltrating water, and thus contaminants after closure.

The waste tank grout fill formulation specifications (C-SPP-F-00055 Rev 4) are designed to ensure the cured grout meets the HTF PA assumptions. The HTF PA contains assumptions regarding both mechanical and chemical properties of the tank fill grout. These assumptions pertain to the grout's performance with respect to 1) grout chemical properties, 2) waste tank stability, 3) inadvertent intruder prevention, and 4) tank flow modeling.

The alternative fill grout (meeting the requirements of Specification C-SPP-Z-00012) that is proposed to be used to cap the last few feet of the Tank 16 primary and annulus may not meet all of the assumed mechanical and chemical properties for grout material as specified in the HTF Tank Farm PA, but will still perform satisfactorily so that the Tank 16 closure performance objectives are met. It should be noted that non reducing grout (Controlled Low Strength Material (CLSM)) was used for bulk fill previously on Tanks 17 and 20 (PIT-MISC-0004), and the alternative grout formula proposed (Specification C-SPP-Z-00012, Rev. 1) was used as a clean cap grout in the Saltstone Disposal Facility (SDF).

Performance Assessment Grout Assumptions

Residual contaminants will be stabilized by filling the storage tanks with grout after the removal of waste. Grout is composed primarily of cement, sand, water, fly ash, slag, silica fume, viscosity modifier and high range water reducer. The grout mix must be flowable, pumpable and self-leveling. Grout is commonly used to solidify and stabilize radioactive wastes and the technology is at a mature stage of development. Stabilization with grout maintains the tank structure and minimizes water infiltration over an extended period of time, thereby impeding the release of stabilized contaminants into the environment. [DOE/SRS-WD-2014-001]

Grout will be used to fill the entire volume of the Type I, II, III/IIIA and IV tanks. Operational closure activities will be carried out using reducing grout to minimize the mobility of certain redox sensitive contaminants after closure (e.g., Tc-99). The grout formula is alkaline because grout is a cement-based material that naturally has a high pH, which is compatible with the carbon steel tank liner. The tank fill grout typically has a high compressive strength and low permeability, enhancing its ability to limit the migration of contaminants after operational closure. [SRR-CWDA-2010-00128]

The grout attributes important to tank operational closure are:

- Low hydraulic conductivity
- High pH
- Low E_h
- High degradation resistance
- High flowablity
- Self-leveling
- Low bleed water
- High compressive strength

Grout requirements consist of both mechanical and chemical properties. The mechanical requirements of the grout are adequate compressive strength to withstand the overburden load and provision of a physical barrier to discourage intruders. The chemical requirements of grout include high pH and a low E_h. Table 1 outlines some of the key properties captured in the HTF PA.

Table 1: Mechanical and Chemical Properties for Grout

Properties	Attribute
Rheology	ASTM D 6103 - 04
Cure Time	< 28 hours
Compressive Strength (nominal)	2,000 psi
Leveling Quality	Self
Segregation	Minimal
Heat of Hydration	Low Heat Mass Pour
Initial E_h	< 0 mV
Initial pH	> 12.5

[Table 3.2-9, SRR-CWDA-2010-00128]

Grout is composed primarily of cement, sand, water, fly ash, slag, silica fume, viscosity modifier and high range water reducer. The grout mix must be flowable, pumpable and self-leveling. Previous grout studies evaluated the chemical and mechanical properties of grout for tank closure. [SRNL-STI-2011-00551, WSRC-STI-2007-00369]

Grout Chemical Properties

The HTF PA assumes that the chemical properties (e.g., reducing capacity) of the fill grout changes as a function of pore volume flushing [SRNL-STI-2012-00404]. Once enough water flows through the pore volumes of the grouted waste tank, these models assume that the fill grout chemical properties transition from reducing to oxidizing conditions. Because the timing of these transitions is determined based on grout formulation, the grout components (e.g., slag quantity) were developed with specific chemistry impacts (e.g., extended reducing capacity) in mind. It should also be noted that while the PA waste release analyses assumed a nominal slag composition [Table 2, SRNL-STI-2012-00404] for modeling purposes, the modeling recognized that "small deviations from these nominal values on rates of grout degradation would be small relative to the effects of other uncertainties". [SRNL-STI-2012-00404]

Assumed Grout Properties in the HTF PA and Impact of Using Alternative Grout

The HTF closure documents contain assumptions regarding both mechanical and chemical properties of the tank fill grout. These assumptions pertain to the grout's performance with respect to 1) grout chemical properties, 2) waste tank stability, 3) inadvertent intruder prevention, and 4) tank flow modeling. These grout performance areas and their implications with respect to assumed performance are addressed in additional detail below.

Grout Chemical Properties

Using an alternative grout formula as Tank 16 fill grout while completing the final Tank 16 primary and annulus grout lifts (maximum of 84,000 gallons in primary and 10,280 gallons in the annulus) would not impact the tank grout's overall effective reducing capacity, since the alternative grout has a greater weight percent slag than the nominal tank grout (45 wt% slag per C-SPP-Z-00012, Rev. 1 versus 30 wt% slag per C-SPP-F-00055, Rev. 4). In addition, the tank volume affected by the alternative grout formula is less than 10 percent of the total tank grout (Tank 16 is a Type II Tank with a nominal operating volume of over one million gallons) and the affected grout is near the tank top, not near the residual waste, where the grout's reducing capacity would most impact chemical conditions of concern.

Waste Tank Stability

In the HTF PA, it is assumed that the entire waste tank is filled with grout and therefore structural failure (i.e., collapse) is not considered. Section 3.2.3 of the HTF PA references an adequate compressive strength (i.e., 2000 psi per PA Table 3.2-9) to withstand the overburden load on the tank at closure. The alternative grout used to fill the Tank 16 primary may not have a cured compressive strength of 2000 psi, but since alternative grout use is limited (maximum of 84,000 gallons in primary and 10,280 gallons in the annulus) and since using alternative grout will minimize Tank 16 voids, it is reasonable to conclude that overall tank stability will be maintained.

The long-term structural behavior/integrity of a grout filled waste tank was evaluated previously through calculation [T-CLC-F-00421]. This calculation stated that because the grout-filled tanks are essentially monoliths of grout in the ground, structural collapse cannot occur. The analyses concluded that these mechanisms would not cause the grout filled waste tank to crack. With regard to stability and tank collapse prevention, the calculation assumed that tank was filled with grout to prevent large void formation. The alternative grout used for final fill may not have a 2000 psi compressive strength as assumed in the HTF PA, but the alternative grout will limit void formation and therefore does not impact the fill grout material's overall functionality with regards to tank stability.

Waste Tank as Inadvertent Intruder Barrier

Multiple elements of the waste tank design serve as inadvertent intruder barriers. The HTF closure cap, waste tank concrete roof, and waste tank grout fill are considered sufficient to prevent drilling into the waste form given well drilling practices in the region and the presence of nearby land without underground concrete obstructions. The presence of the earthen cover and the intruder barrier will prevent the worker from coming in contact with the waste form during construction of a basement for a residence as an inadvertent intruder. The fact that an alternative grout formula will be used as Tank 16 fill grout while completing the final Tank 16 primary and annulus grout lifts will not impact the ability of the waste tank design elements to serve as inadvertent intruder barriers.

Tank Flow Modeling

The tank grout minimizes the flow of water from the tank top to the contamination zone at the bottom of the tank. The HTF PA describes the assumed grout material properties in PA Section 4.2.2.2.4. The properties assumed in the modeling were selected from the testing described in WSRC-STI-2007-00369 and SRNL-STI-2011-00551, and are shown in PA Table 4.2-28 and PA Figure 4.2-30. The grout formula was developed to meet the assumed material properties (SRNL-STI-2011-00551), with conformance to the grout formulation validated through adherence to the grout specification requirements.

The alternative grout used for final fill will minimize the potential for voids forming, but the volume grouted with the alternative grout (maximum of 84,000 gallons in primary and 10,280 gallons in the annulus) may not meet assumed HTF PA hydraulic properties. Since the alternative grout will be placed well above the tank waste layer, impact on contaminant retardation is irrelevant, but not meeting the HTF PA assumed hydraulic properties can change the water infiltration rate to the waste layer. The alternative grout could have a slightly higher hydraulic conductivity than the typical reducing grout (meeting C-SPP-F-00055), but the small percentage of the grout monolith allowing slightly faster flow would have only a minor effect on the overall flow past the residual waste layer, and would remain hydraulically similar to the base case model. The impact the alternative grout (per C-SPP-Z-00012, Rev. 1) would have on saturated hydraulic conductivity was evaluated previously (SRR-CWDA-2014-00011) and the evaluation concluded that the alternative grout would have a saturated hydraulic conductivity better than that assumed for the SDF modeling (6.4E-09 cm/s). This expected saturated hydraulic conductivity is comparable to what was assumed for HTF grout (2.1E-09 cm/s).

To bound the impact that using an alternative grout might specifically have on Tank 16 fate and transport modeling, the HTF Goldsim model was run deterministically with an increased infiltration rate (16.45 in/yr versus 11.67 in /yr) and with the entire grout monolith hydraulically degraded faster than anticipated (flow run 17 in Table 5.6-7 of the HTF PA). Even under these grossly conservative conditions, the impact on peak contaminant release is minor as shown in Figures 1 and 2. The 1-meter and 100-meter peak doses associated with Tank 16 are still well below the peak HTF doses documented in the Tank 12 Special Analysis (SRR-CWDA-2015-00073), albeit occurring earlier in time.

Figure 1: Total Dose at the 100-meter boundary (T16 Only)

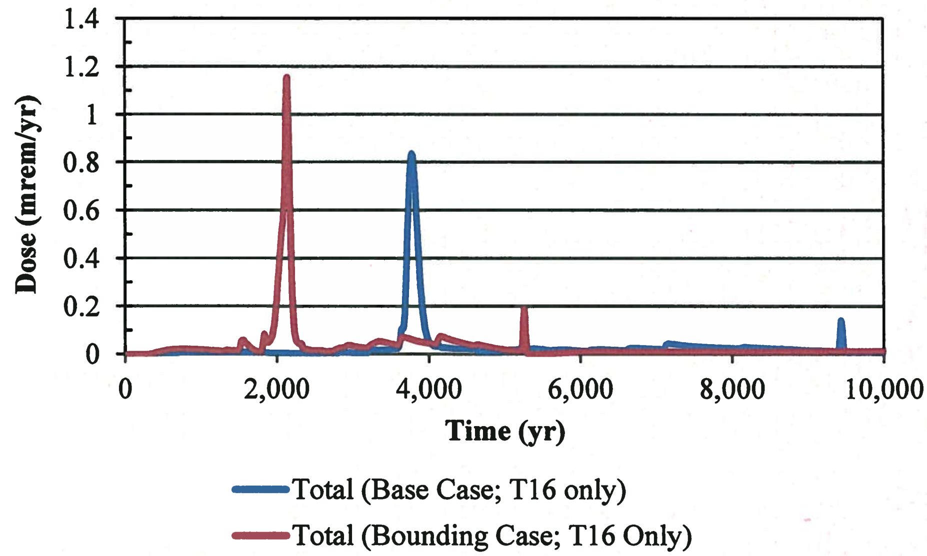
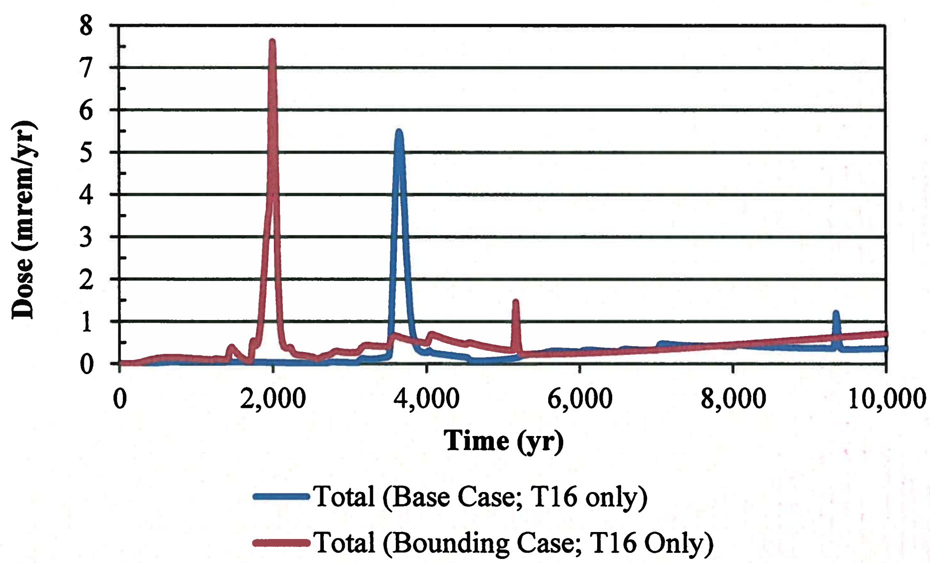


Figure 2: Total Dose at the 1-meter boundary (T16 Only)



<u>Conclusion</u>

Use of an alternative fill grout meeting the requirements of Specification C-SPP-Z-00012 while completing the final Tank 16 primary and annulus grout lifts can be carried out in compliance with the HTF Performance Objectives detailed within the PA. Use of the alternative grout formula with an increased grout flowability is desired in order to minimize the potential for voids during the final Tank 16 grout pours.

References

1. C-SPP-F-00055, Rev. 4, *Furnishing and Delivery of Tank Closure Grout*, Savannah River Site, Aiken, SC, December 2012.
2. C-SPP-Z-00012, *Vault 4 Clean Cap Grout*, Procurement Specification, Savannah River Site, Aiken, SC, Rev. 1, March 2014.
3. DOE/SRS-WD-2014-001, Rev.0, *Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site,* Savannah River Site, Aiken, SC, December 2014.
4. PIT-MISC-0004, *Industrial Wastewater Closure Module for the High Level Waste Tank 17 System*, Savannah River Site, Aiken, SC, Rev. 2, August 1997.
5. SRR-CWDA-2010-00128, *Performance Assessment for the H-Tank Farm at the Savannah River Site,* Savannah River Site, Rev. 1, Aiken, SC, November 2012.
6. SRNL-STI-2011-00551, Langton, C. A., and Stefanko. D. B., Rev. 1, *Tanks 18 and 19-F Structural Flowable Grout Fill Material Evaluation and Recommendations*, Savannah River Site, Aiken, SC, April 2013.
7. SRR-CWDA-2014-00011, *Evaluation of Vendor Supplied Clean Cap Material for Saltstone Disposal Units*, Savannah River Site, Rev. 0, Aiken, SC, March 2014.
8. SRR-CWDA-2015-00073, *Tank 12 Special Analysis for the Performance Assessment for the H-Tank Farm at the Savannah River Site*, Savannah River Site, Rev. 0, Aiken, SC, August 2015.
9. SRNL-STI-2012-00404, Denham, M., and Millings, M. R., *Evolution of Chemical Conditions and Estimated Solubility Controls on Radionuclides in the Residual Waste Layer During Post-Closure Aging of High-Level Waste Tanks*, Savannah River Site, Aiken, SC, August 2012.
10. WSRC-STI-2007-00369, Rev. 0, Dixon, K., and Phifer, M., *Hydraulic and Physical Properties of Tank Grouts and Base Mat Surrogate Concrete for FTF Closure*, Savannah River Site, Aiken, SC, October 2007.
11. T-CLC-F-00421, Carey, S.A., *Structural Assessment of F-Area Tank Farm After Final Closure*, Savannah River Site, Aiken SC, Rev. 0, December 18, 2007.

cc: J. E. Occhipinti, 704-56H
J. W. Rush, 241-162H
R. O. Voegtlen, 241-162H
J. R. Cantrell, 705-1C
S. A. Thomas, 705-1C
S. P. Simner, 705-1C
B. A. Martin, 705-1C
L. B. Romanowski, 705-1C
J. P. Pavletich, 705-1C
L. K. Pressley, 705-1C